INCREASE
Partnerships and Universities
Brookhaven National Lab

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Strategy Forward

- Identify a unifying theme that drives research in a variety of synergistic disciplines.
- Use BNL's NSLS and NSLS-II Synchrotrons and other facilities as a resource.
- Increase historically underrepresented faculty and student usage of BNL facilities.
- Make major contribution to advancing knowledge in the thematic area.

Example

- Energy Storage for Electricity Production and Transportation
  - Advance Renewables (solar, wind, etc.)
  - Speed up widespread use of electric vehicles
- http://www.aps.org/policy/reports/popa-reports/index.cfm

TECHNOLOGIES & DISCIPLINES

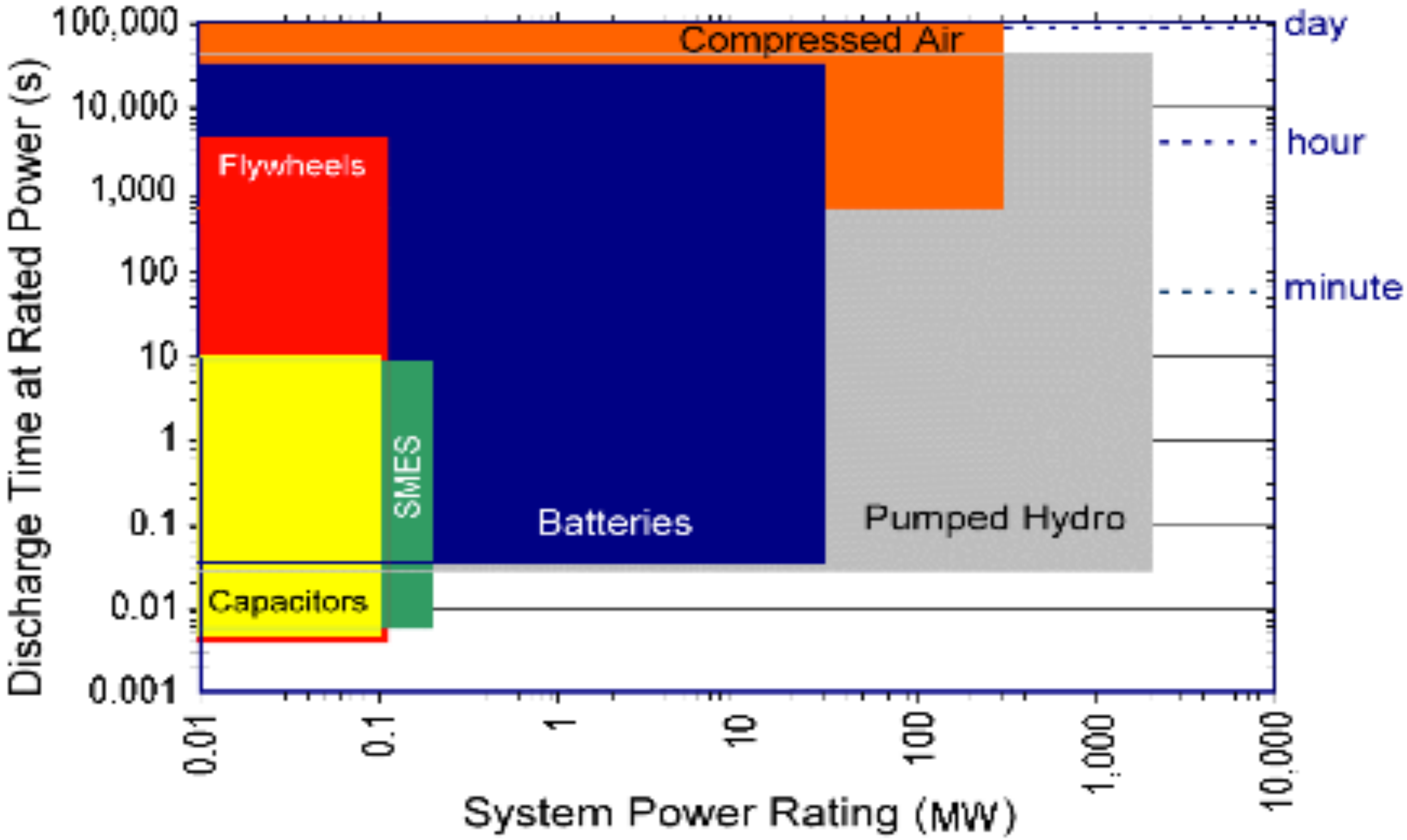
- Pumped Hydropower (Mechanical & Civil Engineers, Environmental Scientists)
- Batteries (Chemists and Chemical Engineers)
- Flywheels (Mechanical Engineers, Material Scientists)
- Compressed Air Energy Storage [CAES] (Aerodynamic engineers, Physicists)
- Supercapacitors [Electrochemical Capacitors] (Chemists & Chemical Engineers)
- Superconducting Magnetic Energy Storage (Physicists, Mechanical Engineers)

TECHNOLOGY STATUS

Commercial	Pre-commercial Prototype	Demonstration Stage	Developmental
Pumped Hydro Flywheels for power quality applications at the consumer site	CAES Lead-Acid Battery[1] Ni-Cad Battery[1] Sodium-Sulfur Battery Flywheel (as load device) Micro-SMES (as load device)	Zinc-Bromine Battery Flywheel (as grid device) Vanadium Redox battery[2] Electrochemical capacitor	Lithium-Ion Battery for grid applications SMES (as grid device) Electrochemical capacitors Other advanced batteries

1. Commercial in utility emergency backup power applications
2. Commercial in telecom applications < 15 kW

TECHNOLOGY CAPABILITIES



FUNDAMENTAL RESEARCH NEEDS

Materials Research: Development of new materials has the potential to impact nearly all energy storage technologies. For example, nanomaterials are clearly promising for high surface area applications, such as batteries and electrochemical capacitors. Advancements in nanomaterials may impact technologies where high strength materials are needed, such as flywheels, SMES, and containment vessels for CAES. Advances in superconductivity can yield materials that are easy to manufacture and durable for SMES applications and flywheel bearings. Several current and future storage technologies would benefit from the identification and development of new materials that can support high energy densities. Materials that are made with the goal of applications to electricity storage technologies should have low cost, long lifetime, and the ability to withstand repeated mechanical, thermal and/or electrical cycling. High temperature thermal energy storage materials are of particular interest.

Power Conversion Systems (PCS): A PCS typically contributes over 20% to the overall energy storage system costs and is a critical technology. Current work on SiC-based devices shows promise in improving the overall performance of PCS, but more research is needed in a variety of areas to further optimize these devices. Areas in need of attention include semiconductor switches, device cooling, packaging and methods for integrating multiple energy storage systems with the grid. Due to the modular nature of the technology, it is important to develop and standardize systems, allowing industry to use PCS "off the shelf".

Computer Modeling: As new electricity storage technologies come into use, the electric power industry will need tools to predict their behaviors as they are integrated into existing transmission and delivery systems. Improved simulation capabilities will allow utilities to better assess which technologies best meet their needs. Many current simulations do not account for renewable energy sources, which will undoubtedly be a part of the next generation transmission and distribution systems. A better understanding of how renewables link to storage systems and integrate into the grid will help increase their penetration.

Manufacturing Techniques: The development of new electricity storage technologies will require novel fabrication techniques for future generations of materials, such as nanomaterials. Particularly in the areas of batteries and capacitors, manufacturing processes will need to be made reliable, inexpensive and safe for workers and the environment. Where possible, the manufacture of components for electricity storage systems should build on the experience of other industries; however, this will not be sufficient, and the development of new techniques should be a high priority.

Integration: If current trends continue, it seems probable that the grid of the future will have to incorporate power generated on a fairly small scale by many renewable technologies, such as wind and photovoltaics. Storage could play an important role in allowing this integration and deeper market penetration. Hence, research is needed on technologies and control systems that will allow this to be done with minimal energy loss and without disrupting the operation of the grid.

NEXT STEPS

- Explore this and other ideas.
- Establish a Panel of External Reviewers to evaluate which idea has the best chance of being funded by NSF as well as achieve technological success.
- Prepare White Paper.
- Prepare Proposal to NSF's STC Program.